

APPENDIX G- GEOTECHNICAL

GENERAL

This section summarizes the results of the Geotechnical Design, including field investigations and subsequent geotechnical analyses performed to support the project design. The following paragraphs describe the geotechnical investigations and analyses for the levee and floodwall along the Colorado River and for the levee along Baughman Slough.

GEOLOGY

The City of Wharton is located on the Coastal Plain of Texas, which is mainly a low-lying coastal plain with limited topographic relief that gradually rises from sea level in the east to as much as 900 feet in the north and in the west. The surface geology of the Coastal Plain is complex due to cyclic deposition of sediments and to repeated sea-level changes and natural basin subsidence that has produced discontinuous beds of sand, silt, clay, and gravel. The Coastal Plain is underlain by a massive thickness of sediments that form strata having the same dip (homocline). Several major rivers dissect the Coastal Plain and flow nearly perpendicular to the Gulf of Mexico; these rivers include the Sabine, Trinity, Colorado, Guadalupe, Brazos, San Antonio, and Rio Grande Rivers. During the Late Tertiary and early Quaternary Ages, the river systems brought in huge quantities of clay, silt, sand, and gravel from upstream sources. These sediments were spread over the Coastal Plain as the rivers shifted laterally over the nearly featureless coastal prairie. The City of Wharton is located on the east bank of the Colorado River. Caney Creek, which flows through Wharton immediately north of the main business district, occupies a former course of the Colorado River. The geology and the general soils of the project area are of the Holocene Age, as recent alluvium along the Colorado River, and of the Pleistocene Age, as older sediments underlying the alluvium and are of the Houston Group. The Houston Group is divided into two formations, the Lizzie, at the base, and the Beaumont, at the top. These formations both outcrop in Wharton County, with the Lizzie Formation outcropping only in the extreme northern portion of the county. The surface and near surface soils throughout the City of Wharton are alluvial in origin and generally consist of moderate to high plasticity clay (CL to CH) with sand at depth. The clay has low permeability, high water holding capacity, and poor drainage. The clay also has very high shrink-swell potential and exhibits high corrosivity for uncoated steel.

GEOTECHNICAL INVESTIGATIONS

Geotechnical investigations were performed for this feasibility study of the Wharton, Texas, Local Protection Project along the east bank of the Colorado River and along the south bank of Baughman Slough. A total of six geotechnical borings were drilled and sampled for this project. The investigations are discussed in more detail in the following paragraphs:

COLORADO RIVER

Five geotechnical borings, designated as Borings 06-75 through 06-78 and Boring 06-80 were drilled at predetermined locations along or near the Colorado River on 16 March 2006, with 24-hour water table readings taken on 17 March 2006. Borings 06-74 and 06-79 were not investigated because of right-of-entry concerns. All borings were continuously sampled. All borings were advanced with hollow-stem augers with sampling through the hollow stems. Thin-walled samplers (3-inch diameter Shelby tubes) were used to obtain samples of cohesive soils and split-spoon samplers were used to obtain samples of cohesionless soils. Sampling of

cohesionless soils coincided with the performance of Standard Penetration Tests (SPT). All samples were visually classified in the field. The consistency of each undisturbed cohesive sample was measured in the field with a hand penetrometer. Selected samples of cohesive soils were tested in the laboratory for moisture content, unit weight, Atterberg limits, grain size, and shear strength. The locations of the borings along the Colorado River are shown on Plates C-111 through C-129. The logs of those borings are shown on Figure 4-1.

BAUGHMAN SLOUGH

One geotechnical boring, designated 06-81, was drilled on the south side of Baughman Slough, along the north end of the City of Wharton, on 16 March 2006, with the 24-hour water table reading taken on 17 March 2006. This boring encountered only high plasticity clay (CH) through the full depth drilled. This boring was continuously sampled using thin-walled samplers (3-inch diameter Shelby tubes). All samples were visually classified in the field. The consistency of each undisturbed cohesive sample was measured in the field with a hand penetrometer. Selected samples of cohesive soils were tested in the laboratory for moisture content, unit weight, Atterberg limits, grain size, and shear strength. The log of Boring 06-81 is shown on Figure 4-1. The location of Boring 06-81 is shown on Plate C102.

SUBSURFACE CONDITIONS

The alluvial soils along the Colorado River are relatively uniform throughout the City of Wharton. Very minor variances in soil composition can be noted. The variance in subsurface conditions at boring locations along the Colorado River are the result of fills and disposals. Boring 06-75, located in the City of Wharton sewage disposal facility, encountered fill as high plasticity clay (CH) mixed with debris to a depth of 9 feet. Boring 06-76, located in a City park adjacent to the Colorado River encountered only natural soils. And, Boring 06-77, located at the river park at the end of Elm Street, encountered fill as sand and gravel, plus asphalt and concrete rubble during two attempts to drill to the prescribed depth at this location before the location was abandoned. The City of Wharton has grown and developed along the Colorado River for over 150 years and the channel slopes of the Colorado River have served both as a location for disposal of fill and rubble and as a location for structural development. The borings along the Colorado River indicated that the natural subsurface soils are predominately stiff, high plasticity clays (CH) overlying sand at a depth of about 20 feet. Within the City landfill, Boring 06-78 encountered trash and other debris, as to be expected, to a depth of about 15 feet. Below 15 feet, the natural soils encountered in Boring 06-78 were high plasticity clay (CH) to about 16 feet overlying sandy clay with interbedded layers of sand to the bottom of the boring. Boring 06-80 encountered natural soils as stiff, high plasticity clays (CH) with slickensides and a thin layer of clayey sand (SC) at a depth of about 15 feet. Boring 06-81, along the south side of Baughman Slough, encountered stiff, high plasticity clays to the full depth of the boring at 20 feet.

GROUNDWATER CONDITIONS

The only 24-hour water levels observed were in Boring 06-78 at a depth of 7.2 feet and in Boring 06-81 at a depth of 14.0 feet. All borings were advanced with hollow-stem augers and no water was encountered in any boring during drilling. No groundwater was encountered in the borings along the Colorado River for the 24-hour water table readings. Boring 06-78 was located in City of Wharton landfill and the water level coincided with the depth of the trash/fill zone in the subsurface. This groundwater in Boring 06-78 is most likely perched water in the pervious trash/fill overlying the more impervious natural soils at greater depth. The groundwater readings indicate, in general, that groundwater should not be expected to be encountered during construction of this project. Seasonal perched water and surface flow from storm water runoff may be encountered on an intermittent basis.

LABORATORY TESTING

GENERAL

All laboratory soil tests were performed in accordance with the appropriate American Society for Testing and Materials (ASTM) standards. Visual classifications were made of all soil samples. Laboratory testing of selected samples of cohesive soils consisted of the determination of moisture content, dry unit weight, Atterberg limits (liquid limit and plastic limit), grain size (sieve) analyses, and of shear strength, as unconfined compression strength. Laboratory tests were not performed on the cohesionless soils. Plots of laboratory test results are presented in Figure 4-2 through Figure 4-5.

SHEAR STRENGTH

The short-term shear strengths of selected samples of undisturbed cohesive soils were determined in the laboratory by performing unconfined compression (UCC) tests. The long-term shear strengths of subsurface soils were estimated from other projects in similar geologic settings. The shear strengths of cohesionless soils for all loading conditions were based on correlations between blow counts, from Standard Penetration Tests (SPT), and angles of internal friction, ϕ . For fissured or slickensided clays, the short-term shear strength was assumed to be a cohesion of 1000 psf and the long-term shear strength was assumed to be an angle of internal friction, ϕ , of 17 degrees, as determined from past experience on projects in the area with similar soils. The design shear strengths for long-term (steady state) loading and for short-term (end-of-construction) loading are presented in Table 4-1.

Table 4-1. Design Shear Strengths

Soil Types	Long-Term Loading ϕ (degrees)	End-of-Construction Loading and Bearing Capacity C (psf)
Stiff Clay	25	2000
Slickensided Clay	17	1000
Silty Sand (SM) Clayey Sand (SC)	30	0

Figure 4-2
Water Content Versus Depth

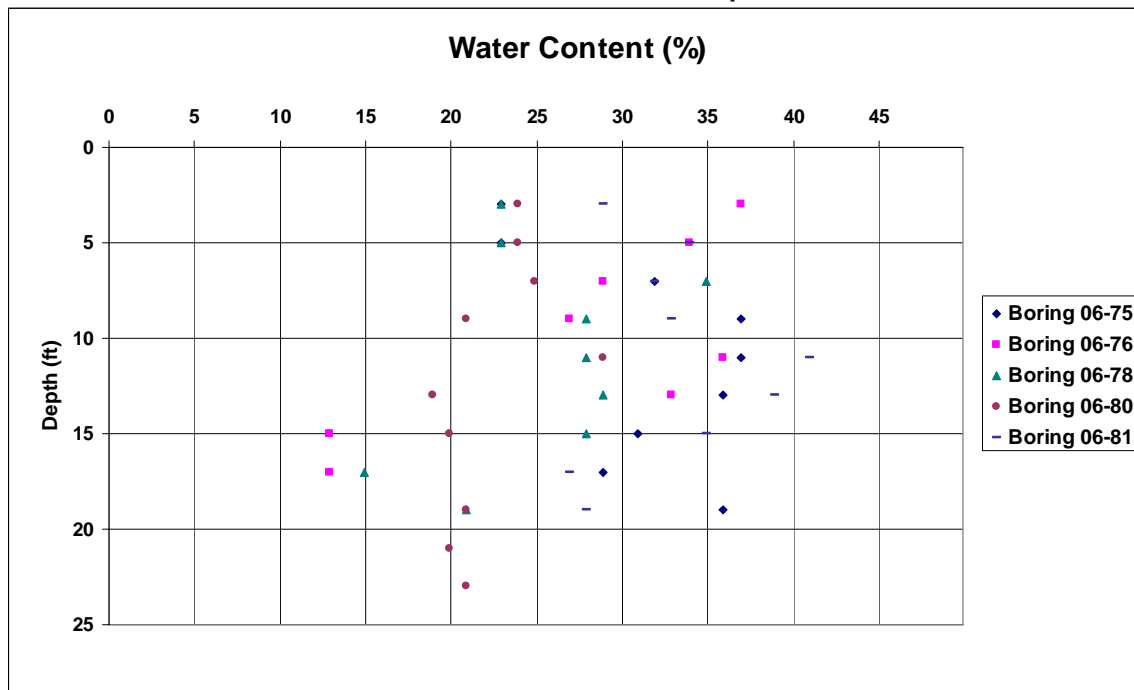


Figure 4-3
Liquid Limit Versus Depth

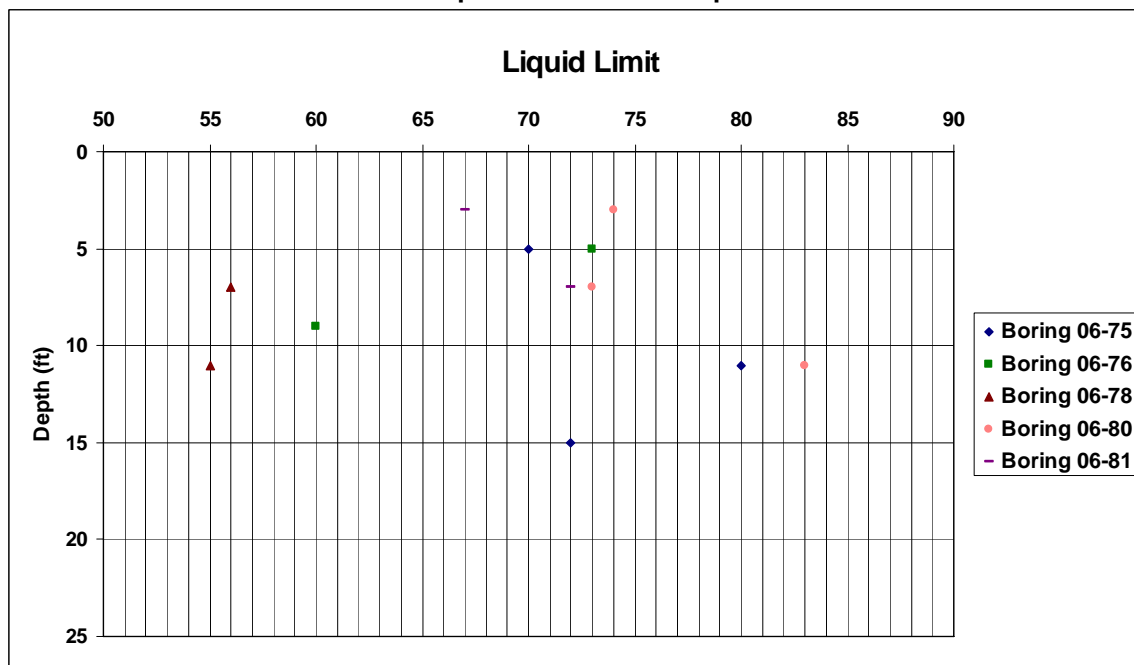
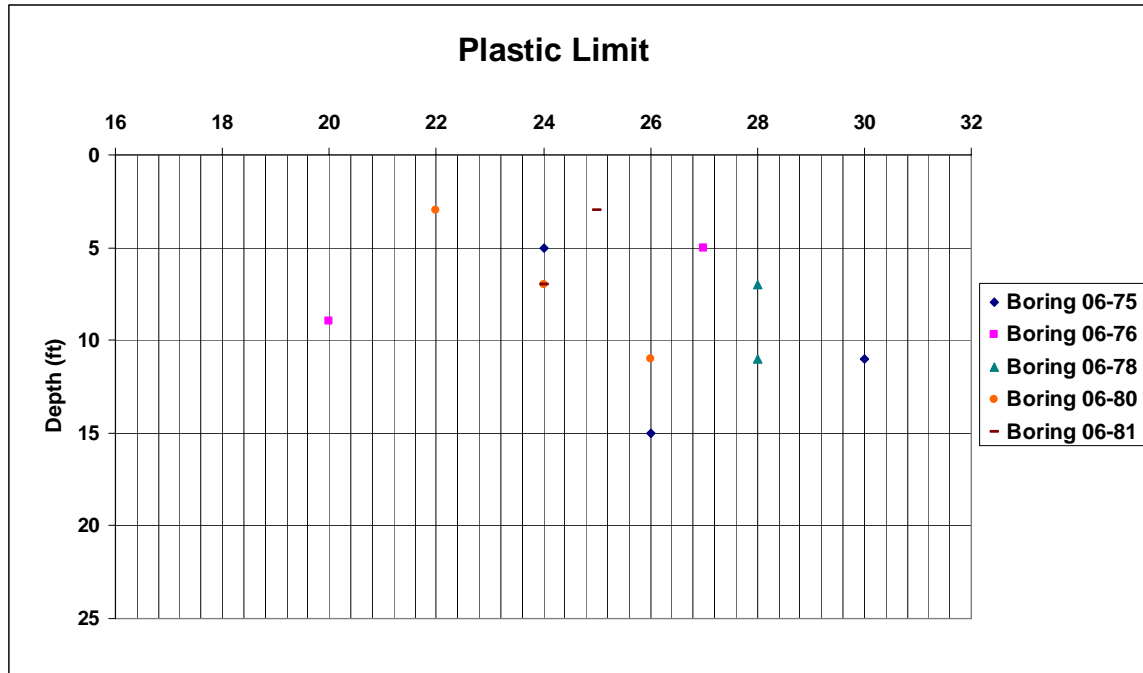


Figure 4-4 Plastic Limit versus Depth



LEVEES

The levees along the Colorado River for this Local Protection Project are expected to be, for most of the alignment, less than 10 feet in height and the levees along Baughman Slough are expected to be less than 6 feet in height. Low levees, as proposed for this project, on proven foundations do not require extensive stability analyses. Side slopes of 1v-on-3h are the steepest slopes that can be mowed with conventional equipment and are adequate for long-term stability for the proposed levees of this project. The crest of the levee should be 10 feet (minimum) for access, especially during floodfighting. The levee should be constructed as a homogeneous earthfill section with no internal embankment zoning. Borrow material from the required excavation for internal drainage channels and from selected borrow areas will be satisfactory for construction of the levee embankment. A well-maintained grass slope should provide adequate slope protection for both the riverside and landside slopes of the levee. This evaluation assumes that satisfactory clays and sandy clays will be selected as fill; clayey silts, sandy silts, and silty sands should not be used for construction of the levees. Clay soils with liquid limits (LL) greater than 60 should be avoided if practical to reduce the cracking of the slope surface during extended dry periods. The levee foundation should be stripped a minimum of 6 inches and those stripped materials should be stockpiled for later use as topsoil. Additional geotechnical investigations along the levee alignment should be undertaken during more detailed design, particularly at locations of stream and ditch crossing and at locations of ponding areas near the levee alignment. At these particular locations the levees will be higher than the remainder of the alignment and may require more evaluation. Geotechnical investigations should be undertaken in ponding areas or other potential borrow sources to better define the potential borrow material for the levee embankment, which also may result in less desirable materials and the need for more evaluation of the levee design. With the additional geotechnical investigations, stability analyses should be performed on critical sections of the levee along the Colorado River, especially if the levee alignment brings the levee close to the river, which could impair the overall stability of the levee.

Inspection trenches should be excavated along the centerlines of the levee alignments to expose any waterlines, sewer lines, or other utility conduits, as well as unsuitable material and other debris. The depth of the inspection trench along the levee alignment at the Colorado River should be 6 feet or equal to the height of the levee, whichever is less. The inspection trench at the Colorado River levee should be excavated with a 8-foot minimum bottom width and 2h:1v side slopes. The depth of the inspection trench along the levee alignment at Baughman Slough should be 4 feet or equal to the height of the levee, whichever is less. The inspection trench at Baughman Slough should be excavated to a width sufficient for compaction of backfill with a hand compactor and with 0.5h:1v side slopes. Prior to the first layer of fill material, the surface of the levee foundation should be disked, adjusted to the proper moisture content, and compacted with a sheepsfoot-type roller. The subsurface conditions appear adequate relative to stability and to underseepage restriction for levees downstream of about Resident Street and upstream of Highway 59, and special measures to restrict seepage are not required. For the approximately 300 feet between Resident Street and Highway 59, excavation and removal of pervious debris is recommended, as discussed in FLOODWALLS, below.

The proposed alignment of the levee should be revised to permit the levee to be constructed around the end of the embankment for the approach to the railroad bridge over the Colorado River to provide assurance of seepage cut-off of the levee. If the levee ties to the railroad embankment, transition sections of the levee should be used to widen the levee contact with the railroad embankment. A filter blanket should be incorporated into the levee section at the railroad embankment to intercept and discharge seepage. The alignment should also be revised to construct the levee around the north end of the City landfill. The levee through the landfill should be designed with 1v-on-4h side slopes to increase the seepage path through the levee foundation and compensate for trash and debris in the foundation soils. Additional geotechnical investigations should be performed for final design to better ascertain the character of the landfill levee. For ravines and other drainage paths crossing the levee alignment, the ravine or path should be cleared of vegetation and grubbed of all significant root masses. Unsatisfactory soils within the ravine or path should be removed prior to initiating construction of the levee.

Table 4-2. Levee Features

Side slopes	1v-on-3h	
Crest width	10 feet	Minimum
Stability berms	No	
Embankment zoning	No	Homogeneous
Seepage cutoff	No	
Slope protection, riverside	Grass	
Slope protection, landside	Grass	
Soil type	Clay	CL/CH

EXCAVATIONS

Excavations deeper than 4 feet, as interior drainage channels and as temporary excavations for structures, should be limited to slopes no steeper than 1v-on-3h. Stripped material obtained prior to excavation should be stockpiled for later use as topsoil. The unlined portions of the slopes of interior drainage channels should be plated with topsoil and turfed. Dewatering in advance of excavations should not be required. Groundwater levels observed during geotechnical investigations were beyond the bottom elevations of potential excavations. Some perched water could be expected for some time after heavy rains and sump pumps may be needed to remove any of this water that enters the excavations.

FLOODWALLS

Floodwalls have been proposed to provide flood protection along a portion of the Colorado River near the main business district of the City of Wharton. This portion of the project alignment is too narrow and restrictive for the construction of earthfill levees. This portion of the alignment has been used as a disposal area for concrete and asphalt rubble, as well as other construction debris, as determined during geotechnical investigations. The upper subsurface soils to about 8 feet are construction rubble, or contain substantial amounts of construction rubble. The length along the alignment of this construction rubble is estimated to extend from Resident Street on the east to Highway 59 on the west, for about 300 feet. The construction rubble in the subsurface should be expected to create distinct seepage paths beneath the floodwall foundation. Selective excavation of the construction rubble is recommended with replacement by satisfactory clay, processed and compacted to provide a stable, impermeable foundation for the floodwall. The excavation for the construction rubble should be the width of the floodwall foundation at the base of the excavation with slopes no steeper than 1v-on-1.5h on the sides of the excavation. The bearing capacity of the foundation soils should be computed as if the subsurface soils were uniform clay for short term loading ($\phi = 0$). This reduces the bearing capacity computation to a function of only the cohesion (c), as $q_u = cN_c$ for the ultimate bearing capacity. Floodwalls should be designed for bearing capacities not to exceed 2000 psf, as shown elsewhere in this report. A toe drain, with a perforated collector pipe of at least 4-inch diameter, or trench drain is recommended along the landward edge of the floodwall foundation to intercept any seepage through the foundation soils.

STONE PROTECTION

The placement of riprap or other erosion protection at the water control structures, basin overflow weir, outfalls, and bridges was investigated. The recommended stone protection will consist of an 18-inch layer of riprap to be placed on a 6-inch layer of blanket stone (½-inch to 6-inch). The blanket stone sizes are sufficient to prevent withdrawal of the underlying foundation materials. The use of geotextile beneath the blanket stone is not considered necessary, since the underlying materials are generally cohesive in nature. Gradation requirements are listed in Table 4-3.

Table 4-3. Riprap Gradation (15–265 lbs)

Design Stone Size	Percent of Stone by Weight Lighter Than Design Size	Acceptable Range Weight of Design Stone Size (lbs)
W(100)	100	265-105
W(50)	50	80-55
W(15)	15	40-15

GEOTEXTILE

Geotextile may be required to protect the foundation material beneath riprap for erosion protection, although blanket stone is recommended. The recommended geotextile is a woven geotextile with the minimum requirements listed in Table 4-4.

Table 4-4 Geotextile Design Criteria

PROPERTY	TEST METHOD	UNITS	MINIMUM VALUE
Apparent Opening Size	ASTM D 4751	U.S.Sieve	#40
Permittivity	ASTM D 4491	sec ⁻¹	4.20
Puncture	ASTM D 4833	lbs	150
Tensile Strength	ASTM D 4632	lbs	115
Breaking Elongation	ASTM D 4632	percent	15
Burst Strength	ASTM D 4884	psi	480
Trapezoidal Tear	ASTM D 4533	lbs	40
Percent Open Area	ASTM D 3884	percent	20
Ultraviolet Degradation (percent strength retained at 500 hours)	ASTM D 4355	percent	50
Abrasion Resistance	-	lbs	*

* 55% residual breaking load in any principal direction.

CONSTRUCTION PROCEDURES

The construction of the Wharton, Texas Local Protection Project can be accomplished with conventional construction equipment and procedures. The construction procedures for the various items of work are discussed in the following paragraphs:

CLEARING AND GRUBBING

Some segments of the levee alignment will require extensive clearing and grubbing, most notably south of the sewer treatment facility and west of the city landfill. Clearing within the right-of-way should be limited to the extent necessary to construct and maintain the levee.

EXCAVATION

Excavation for this project should be classified as common excavation. No rock as primary material will be encountered in any excavation for the project. Conventional equipment, such as trackhoes, may be used for excavating the channel and detention basins and for the removal and replacement of construction rubble. For borrow material for the levees, some selective excavation may be required to provide satisfactory material for levee construction. Any excavated material deemed unsatisfactory for levee construction could be disposed in designated placement areas. Containment levees around the placement area will not be required, however the spoil material should be graded for proper drainage.

EARTHFILLS AND BACKFILLS

Satisfactory clays and sandy clays should be selected from the required interior channel excavations and detention basin excavations for use as earthfills and backfills in the project construction. Ideally, clays of low to moderate plasticity, clays with a liquid limit less than 60, should be used in the construction of the levee embankments and in structural backfills. Silts, clayey silts, and silty sands should not be used for levee embankments or for structural backfills. Satisfactory material for construction of the levee embankments should be placed in 8-inch (maximum) thick layers and compacted with a sheepfoot-type roller. Generally, the material should be placed at the natural moisture content. However, the specifications should require adjustment of moisture content when required to facilitate compaction. The target density for compaction should be 95 percent of the maximum dry unit weight of laboratory samples of borrow materials compacted under ASTM D 698, Laboratory Compaction Characteristics of Soil Using

Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. M)). The target moisture content should be from -2 percent to +3 percent of optimum moisture content relative to ASTM D 698. Excessively wet soil, which would require major moisture adjustment, should not be used for fill and should be disposed as spoil. Sloped surfaces against which fill material is to be placed will be stepped or benched to promote bonding of the fill material with foundation material. Borrow materials for levee construction are expected to be obtained from excavations for interior drainage and ponding areas and from borrow areas in the immediate vicinity of the project. Borrow materials should have characteristics similar to the natural soils encountered during geotechnical investigations. In converting borrow quantities, from required excavation or from designated borrow areas, a reduction factor of 15 percent should be used to compensate for volume loss in processing borrow as compacted fill, the construction of haul roads, and loss during transport.

CHANNEL SLOPES

The slopes of interior drainage channels should be plated with topsoil and seeded. Temporary erosion control blankets should be used in bends, lower portions of slopes and other critical areas to assure planting survival.

CARE AND DIVERSION OF WATER

Care and diversion of water during construction will consist primarily of diverting stormwater runoff from the work area. Groundwater is not expected to be encountered and dewatering for excavation will not be required. Any perched water encountered during excavation may be removed by sump pumps.

